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USE OF SUNFISH AND STONEROLLER MINNOWS AS SENTINEL MONITORS OF PCB CONTAMINATION IN FRESHWATER STREAMS IN KENTUCKY

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A PCB monitoring study was conducted on two moderate gradient freshwater streams in western Kentucky, Big and Little Bayou creeks. Stream water, sediment, floodplain soils, and fish were analyzed for PCBs during 1988-2005. A total of 263 water samples were analyzed with only 8 samples showing detectable PCBs. The lack of PCB detections in stream water indicated that PCBs were transitory in the water column and rapidly mobilized into biotic and sediment compartments. A total of 211 and 99 stream sediment samples were analyzed from Big and Little Bayou creeks, respectively. In Big Bayou creek, Aroclor concentrations (Mean ± SEM, µg/g) were 80.23 ± 26.14, 22.75 ± 7.00, and 16.26 ± 6.12 for Aroclor 1248, 1254, and 1260, respectively. Aroclor 1248, 1254, and 1260 concentrations for Little Bayou creek were 120.96 ± 33.00, 49.54 ± 11.66, and 30.83 ± 9.13 µg/g. PCB concentrations were approximately two times higher in Little Bayou creek as compared to Big Bayou creek. One component of this study focused on species-specific patterns of PCB residues in fish, especially the green sunfish (*Lepomis cyanellus*), longear sunfish (*L. megalotis*), bluegill (*L. macrochirus*), stoneroller minnow (*Campostoma anomalum*), largemouth bass (*Micropterus salmoides*), and yellow bullhead catfish (*Ameiurus natalis*). A total of 1248 fish were analyzed for Aroclor 1248, 1254, and 1260. The fish from Big Bayou Creek consisted of 251 stoneroller minnows (SR), 196 green sunfish (GS), 285 longear sunfish (LS), 80 bluegill (BG), 29 largemouth bass (LMB), and 55 yellow bullhead catfish (YBH). Fish collected from Little Bayou creek consisted of 74 SR, 113 GS, 103 LS, 35 BG, 7 LMB, and 20 YBH.

PCB levels for stoneroller minnows from Big Bayou creek were higher and significantly different from levels found in sport fish. Aroclor 1248 and 1260 were not significantly different among the sport fish. Based on frequency of detection, Aroclor 1248 was detected 80% of the time in stoneroller minnows from Big Bayou creek, whereas it was only detected 25-39% in sport fish. In comparison, Aroclor 1254 and 1260 in sport fish were detected 49-69% of the time. These results indicate that higher chlorinated PCBs, such as Aroclor 1254 and 1260, were not readily metabolized and excreted by sunfish. No relationships were found between sunfish age and Aroclor concentrations. These results demonstrated that sunfish exposed to low PCB contamination can effectively regulate PCBs, regardless of age. In addition, at low PCB levels (<0.50 µg/g), green sunfish body burden did not correlate with lipid content. Body burden and fish lipid became more significant with increased PCB concentrations, as observed in fish from Little Bayou creek. A threshold concentration, 0.50 - 1.00 µg/g, had to be exceeded for PCB body burden to correlate with lipid content.

Most sunfish have low lipid content and relative short biological half-life for PCBs, particularly the green sunfish. This makes this organism a good real-time indicator of PCB pollution. Studies by Hutzinger *et al.*(1975) and Sanborn *et al.* (1975; 1977) found this species to be particularly adept at metabolizing organochlorine compounds (DDT, DDE) and PCBs. This field study supports their laboratory findings. Results from this study indicate that sunfish have a unique system of dealing with PCB contamination. A PCB threshold concentration, perhaps 0.50 to 1.00 μg/g, must be achieved for the activation of metabolic pathways and the eventual elimination/excretion of PCBs. The green sunfish either has an enhanced P450 system, or due to low lipid, more rapidly shunts PCBs into metabolic pathways that detoxify this compound. As sentinels the sunfish have restricted home ranges; are easily colonized; and provides an effective way for assessing effectiveness of PCB remediations.

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INFERRING CAUSES OF BIOLOGICAL IMPAIRMENT IN APPALACHIAN STREAMS: WATERSHED-BASED PROBLEM FORMULATION AND INTEGRATION OF MULTIPLE LINES OF EVIDENCE

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ABSTRACT

Human activities such as mining, logging, agriculture and residential development have caused significant biological degradation to many streams of West Virginia, USA. Employing benthic macroinvertebrates as biological indicators of stream health, the West Virginia Department of Environmental Protection (WVDEP) has identified streams across the state that do not meet aquatic life use designations. Therefore, these streams are considered biologically impaired. The development of Total Maximum Daily Loads (TMDLs) is required for all biologically-impaired streams within the state and mandates the identification of stressors to the biological community, so that pollutants can be controlled in each watershed. EPA's Stressor Identification guidance was used to identify and rank physical, chemical, and biological stressors that may have caused impairments to the aquatic community. This process involved the analysis of all available water quality, habitat, physical, biological, historical, anecdotal, and observational data to infer the likely causes of impairment for each stream. A comprehensive conceptual model was developed that provides the linkage between potential impairment causes, their sources, and the pathway by which each stressor can impact the benthic macroinvertebrate community. Data were analyzed using established

water quality standards and stressor-response threshold values were developed based on statistical analysis and reference population data. Quantitative data were plotted and analyzed spatially using a "geo-order" format of assigning relative positions to sampling locations from downstream to upstream for each impaired stream and its tributaries within a subwatershed. Watershed characteristics (e.g. land use and soils), point source inventories, site observations, and other lines of evidence were included in the analysis to identify sources of the stressors.

Stressor Identification required the integration of watershed-based conceptual models of impairment, field biological and chemical monitoring databases, empirical models of biological impairment, and ecotoxicological principles in a strength-of-evidence approach to infer causes of impairment. Candidate causes included known toxic contaminants (metals), conventional pollutants (organic and nutrient enrichment), sedimentation, habitat degradation, and ionic concentration (conductivity). Analysis of some candidate causes was modified by the measures available that documented them. Candidate causes were screened to eliminate those shown not to co-occur with effects. Remaining candidate causes were ranked according to considerations of evidence within each watershed, as well as from statewide empirical models and from other published sources. Strongest inferences were obtained where the independent predictive model agreed with within-watershed observations of stressor measures. Final stressor determinations for each watershed will be used for the development of management plans (TMDL implementation).

KEY WORDS

Stressor identification, bioassessment, streams, TMDL

RELATIVE IMPORTANCE OF WATER AND DIETARY CADMIUM: TOXICITY TO *CERIODAPHNIA DUBIA*

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Key Words: Metals, Cadmium, *Ceriodaphnia dubia*, Trophic Transfer, Dietary Exposure

This study was designed to compare relative importance of water and dietary cadmium on *Ceriodaphnia dubia* reproduction, survival, and feeding rates. Results showed that uptake from water were more rapid than from diet. Both uptakes occurred significantly independent and body burdens were additive from both sources in combined exposure. Furthermore, cadmium trophic transfer between primary producers (*i.e.*, *Pseudokirchneriella subcapitata*) and primary consumers (*i.e.*, *C. dubia*) were observed. Cadmium accumulation increased progressively until organisms stopped feeding. Thereafter, cadmium body burden decreased indicating that cadmium metabolism and excretion were active. However, cadmium biomagnification from algae to *C. dubia* was observed to be minimal. Results also showed that both water and dietary cadmium were chronically toxic for all three endpoints. For example, the LOECs were 5µg/L, 0.60µg/g DW, and 2µg/L+0.26µg/g DW for water, dietary, and combined exposures, respectively. These results suggested that the response was independent of exposure avenues, and the effects in combined exposures were additive. This study demonstrates that dietary cadmium is toxicologically relevant and should be carefully interpreted and considered as part of regulatory assessment of cadmium.

NOTES

THE GRAYWATER STORY AT CURTIS PIKE

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Some members of the Curtis Pike community including Margie Stelzer visited the ASPI demonstration site on the Rockcastle River some years ago. They saw our dry toilets and our constructed wetlands for graywater and were interested in this way of protecting water quality. As they were developing their plans for their community at Curtis Pike they decided that they wanted to have their homes off the grid and use dry toilets and a graywater system to water the garden. They wanted a system that would be acceptable to the county and Commonwealth Health Departments, the environmental divisions of them which oversee the certifying of onsite wastewater systems.

Margie Stelzer searched the web and found the NutriCycle Graywater Root Zone System developed by John Hanson in Jefferson, Maryland. His NutriCycle system is accepted in the State of Maryland and he has over a dozen systems installed and working successfully in Maryland. This gave our Commonwealth people a precedent to allow the installation of two Graywater Root Zone Systems (RZS) at the Curtis Pike on an experimental basis and to certify them.

A plot plan of the Curtis Pike Community with topographical contours, the location of the homes, and the soil conditions were sent to John Hanson. With this information and water usage information, John designed a Root Zone System (RZS) with a dosing system. Because the system waters crops for human consumption, this requires a dry toilet so that the graywater comes only from the bathroom, kitchen sinks and the showers. An in-ground tank is located a little distance from the houses. This tank collects the graywater and, in their case, when it reaches 60 gallons, a dose of graywater is sent through pipe to the RZS, which is downhill from the tank.

The Root Zone System is a set of 4 parallel, level, covered troughs about 6 inches deep and 48 feet long for the Curtis Pike gardens which receive the graywater. The length of the troughs varies with water quantity. A garden of vegetables, fruit trees and fruit bushes is planted on either side of the troughs to make use of the water and the nutrients in the water. The soil bacteria and fungi convert the food particles, fats, soaps and any other contents of the graywater into materials that the plants can use. Obviously, toxic and hazardous chemicals and cleaners must not be put down the house drains since the garden is a living system.

The graywater collecting tank has two dosing siphons which will intermittently send graywater to the top two or lower two troughs in the garden. The dosing siphons were chosen over electric pumps because the community wanted to conserve electricity since they were off the grid and were producing their own electricity from photovoltaic panels. The dosing siphons work somewhat like the flush toilet. When the water rises high enough in the bowl of a toilet, the wastewater flows through the trap below the toilet bowl into the sewerage line. The siphons in the tank are inverted siphons and have a bell on top of them that holds air which is pressurized by the graywater rising in the bell. When the pressure is sufficient it will trip the siphon and send a 60 gallon dose to two of the troughs. The bells and siphons are designed so that they will be alternately triggered, thus feeding one set of troughs and then the other set. When another 60 gallons has reached the tank, the other siphon will trip and send the graywater to the other two troughs. Battery operated dosing counters record the number of doses that are sent to the garden. This indicates the proper operation of the dosing siphons and the number of gallons of graywater sent to the garden.

The system was approved and put into use in the Spring of 2005. The results in this RZS garden are tomato "bushes" over three feet in diameter and four feet high, corn seven feet high with big full ears, and good-sized butternut squash with excellent flavor. These plants grew well in a season when most peoples' gardens withered because of the drought. And this is the water that we "throw out!"

The author oversaw the installation of the system and gave a workshop in April, 2005 on the NutriCycle Root Zone system to the personnel of the Commonwealth and Madison county Health Departments at the Curtis Pike site.